An analysis of the maternal and foetal weight factors in normal pregnancy,

by

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I953.

In matters of science the full significance of observations is frequently not realised until many years have elapsed since the original observations were made. The changes in weight which occur in pregnant women are no exception, and in the ninety one years since Gassner (I3) recorded such weight changes much diligent research has contributed to our knowledge of the changes which do actually occur. Though it is true that the earliest writers noted that maternal weight increase was more than could be accounted for by the palpable and material products of conception and maternal changes, their thoughts must have been far from the pituitary and the adrenal with their relationship to water balance and ionic exchanges in the maternal organism. It is interesting to note, however, that while Gassner was weighing his patients, Addison was laying the foundation of our present knowledge of the adrenal (1849-1855). (I5) Much that is useful has been written about the various aspects of maternal weight gain during pregnancy, though much useful material is lost by way of inadequate statistical analysis. It is to the United States that one must look for most references as the subject does not seem to have interested British workers to the same extent. The multiplicity of writers is matched by

the number of different aspects from which the subject is approached, though the published work may be divided roughly into that which includes toxaemic patients on the one hand, and that which excludes them on the other.

There now seems to be little doubt that water retention with excessive maternal weight gain is often associated with toxaemias of pregnancy. Chesley and Chesley (7) measured extracellular water in 1388 patients and showed that the incidence of pre-eclampsia was six times as great in women who developed excessive extracellular water as in women with normal extracellular water. Zangemeister (42) pointed out the relationship between oedema formation, weight increase and incipient toxaemia and he observed that patients with toxaemia lost an average of 12.31 Kg. during delivery and the first ten days of the puerperium compared with a corresponding loss of 7.54 Kg. in normal patients. Using a similar technique, Stander and Pastore (36) quote 9.36 Kg. as being the loss during delivery and in the first ten days of the puerperium in toxaemic women compared with a loss of 7.65 Kg. in normal women over the same period. Dawson and Borg (10) regard water retention and undue weight gain as "The predominant and earliest morbid phenomenon of

toxaemic pregnancy." They reviewed 93 cases of definite clinical toxaemia, and taking all ages and parities together they demonstrated a 19% increase over what they regarded as being the normal weight gain in pregnancy as a whole, and 54% increase over normal in the last four weeks. Evans (12) studied 52 cases of toxaemia and concluded that "An abnormal increase in weight during any one month is usually an earlier indication of an impending toxaemia than a rise in blood pressure." Hamlin (16), in similar vein, regards it as normal that a young primipara with a low initial blood pressure should gain up to 8 lb. between the twentieth and thirtieth weeks of pregnancy. He states that if she does not gain more she will almost certainly not have pre-eclampsia or eclampsia, but if she does gain more than 8 lb. she will in all probability develop one or other. Harding and Van Wyck (19) declare that gains up to 5 lb. per month are normal. Gains of 5-8 lb. per months they regard with suspicion and gains of 8 lb. or over they regard as indicating potential toxaemia. McIlroy and Rodway (29) quote 11lb. 4½oz. as being the normal average gain in the last sixteen weeks of normal pregnancy (calculated from 900 patients) and 17lb. 4oz. as being the average gain in toxaemic patients (calculated from 75 patients). They think

it of great significance that "...throughout pregnancy the average periodic increase was greatest in the toxaemic group of patients". Wodon (41) studied 400 pregnant women. In 306 who had a normal weight gain he found 24 with some degree of toxaemia, but in 94 who gained more than the normal amount he found 72 who showed signs of toxaemia. He regards 2Kg. as the maximum normal weight gain per four weeks in the last twenty four weeks of pregnancy. Bingham (4) considers ~~that~~ the control of weight by diet and open air exercise as being all important in the prevention of toxaemia, while Randall (32) suggests that women who develop toxaemia lose more weight than normal women early in pregnancy and gain more in late pregnancy. Tompkins and Wiehl (37) present a variation of this theme and show that a normal weight gain in the first two trimesters is associated with a low toxaemia incidence ; if, however, a low rate of gain up to the latter part of the second trimester gives way to a sudden gain towards the end of the second trimester, the incidence of toxaemia is greatly increased.

Siddall and Mack (34), on the other hand, in their study of 100 toxaemic patients, found that excessive weight gain preceded definite signs of

toxaemia in 37 cases, and in the remaining 63 appeared along with, or after, these signs, or not at all. Excessive weight gain was reported in 45% of normal cases. They are critical of the hypothesis that excessive weight gain implies impending toxaemia and quite rightly point out that many normal patients have what appears to be an excessive gain in weight during pregnancy.

The balance of opinion seems to be overwhelmingly in favour of the fact that there is a tendency for women with toxaemia to gain more weight than normally pregnant women. However, statistical methods reveal tendencies and not natural laws, and in the individual case, excess weight gain does not necessarily imply impending toxaemia. The last word has not yet been written on this matter, but for the purpose of this paper one felt that it would be wise to deal only with normal cases. Controversy exists in relation to maternal weight gain and toxaemias of pregnancy, but it exists even moreso in relation to certain other aspects of weight gain in normal pregnancy ; and it is in order that certain normal figures might be established by statistical analysis as a starting point for future investigations into toxaemias, that toxaemic and all other abnormal patients were

excluded from this survey.

Apart from other inadequacies in statistical technique, conclusions have, in the past, been drawn from very small series of cases. Chesley[6], in a paper which covers the literature very comprehensively, lists thirty eight papers which deal with weight changes during pregnancy. In all these papers only five covered a thousand or more cases, and the study of many patients did not begin until well after the end of the first trimester. It is not surprising that so many papers suffer this poverty of numbers, as the task of finding large numbers of normal cases which can satisfy the standards which will be enumerated shortly, is considerable. In the current series some fifteen thousand cases were reviewed before a thousand normal case histories could be produced.

MATERIAL.

The material under consideration consists of 1000 normal mothers who were delivered of 1002 babies. It should be stated at the outset that all cases were booked and delivered in hospital in Cardiff and Crickhowell, and, being delivered in hospital are not a true cross section of all the births in the country in the statistical sense. They were however a random sample of hospital

patients delivered since 1944.

The standards of normality were as follows :-

(i) The mother's first ante-natal visit was at or before twelve weeks gestation. (This eliminated enormous numbers.)

(ii) There was no pre-existing disease in any major system in the mother. Patients with thyrotoxicosis, tuberculosis, chronic renal disease, diabetes mellitus, cardiac defects, essential hypertension etc., were all excluded.

(iii) There was no toxaemia of pregnancy.

(iv) Delivery took place within twenty days of the expected date. (This may seem a rather liberal variation, though it does only represent two days for each lunar month of pregnancy, a very reasonable variation from the normal cycle of menstruation. If pregnancy is represented by ten missed periods, up to twenty days error might be expected on this basis)

(v) The last ante-natal visit took place within a maximum of seven days of delivery.

(vi) A normal live baby (or babies) was produced.

Two Caesarian sections at term were included, as they were performed for simple disproportion due to contracted pelvis in otherwise normal women. Two sets of twins were included and in all calculations, except those relating to the weights

of individual children, their weights were summated. Thus, in comparing weight gain in pregnancy for example, with birth weight, the combined weight of both babies is regarded as the birth weight. In assessing the mean weight of boys and girls separately though, the weights are necessarily separated.

A justifiable criticism might be that three different sets of scales have been used in weighing both mothers and babies. One should point out that these are periodically checked and it was felt that any error, if present, was extremely small.

In estimating the weight gain during pregnancy from the twelfth week one makes use of the assumption made by Kerr [22] and other writers that the weight at this time is about equal to the prepregnant weight of the mother. The weight gain, therefore, from the twelfth week to term represents the total weight gain during pregnancy. A variety of different figures of gain and loss are given as the weight changes which occur in pregnant women between conception and twelve weeks. Chesley [6] reviewing a series of eight papers, gives the weight increase in the first trimester as 2.5 lb. in spite of the anorexia and vomiting which so frequently occur during this period. Cummings [8], perhaps the

most frequently quoted author on this matter, states that " 43,5 % of the patients observed had gastric disturbances and lost 2 - 10 lb., while 56.5 % were normal and showed slight gain in weight". He quotes 0.45 lb. as being the approximate mean gain in the first trimester, and his assessment is based on the patient's statement of her normal weight before pregnancy.

For my purpose I have taken the weight at twelve weeks as being equal to the prepregnant weight for the following reasons :-

(i) That a patient should know her prepregnant weight to within 0.45 lb., when the contents of the stomach, bowel and bladder make it so variable to within 2 lb., seems unlikely.

(ii) A number of authors report a small variable weight loss in the last days of pregnancy. Of Dawson and Borg's[10] patients, 14 % lost weight in the two weeks preceding labour, whereas Evans[12] puts this figure at 36 %. Siddall and Mack[33] state in their review of 460 patients, that 110 lost weight in the last two weeks of pregnancy and Cummings[8] reports that 40 % of his patients lost 1 - 3 lb. in the last two weeks. Stander and Pastore[36] put the average weight loss in the last 7 - 10 days as 1.11 Kg.. Kemper[21] asserts

that 98 % of pregnant women lose an average of I Kg. prior to labour. Mahnert[28] showed an average loss of I Kg. in 40.72 % of his primiparous patients in the three days prior to delivery, while 36.37 % had already lost weight before this. He also showed an average weight loss of I Kg. in 37.5 % of his multipara in the last three days. Momm[3I] studied 20 women over the last ten days of pregnancy and found that 95 % reached their maximum weight before the day of delivery. 22.5 % of the primipara and 22.I5 % of the multipara in McIlroy and Rodway's[29] series lost weight during the two weeks before delivery.

It is apparent therefore, that some small weight loss is to be expected in many normal patients in the last two weeks of pregnancy. It would seem pointless, in view of this, to add a small arbitrary weight at one end of pregnancy and subtract a similar small arbitrary weight at the other, as the patients were not weighed immediately before delivery.

All ages quoted represent the age of the patient on the last birthday prior to her first ante-natal visit.

The duration of labour was also recorded. The actual time of starting labour is notoriously

difficult to assess as such a variety of symptoms and signs may herald its onset. In this series labour was deemed to have started at the time when the patient became aware of regular pains. The time was then measured to the birth of the baby.

In all cases the maternal weight gain was recorded in pounds and also as a percentage of the maternal weight at twelve weeks (or as a percentage of the prepregnant maternal weight, on the basis of the arguments already quoted). The weight of the baby was likewise recorded in pounds, and as a percentage of the maternal weight gain.

All cases, being delivered in the latter part of the war or early post war years were on a more or less fixed diet with regard to vitamin supplements and rationed foods, much moreso than would have been possible in a similar survey in pre-war days when diet was less under the control of external circumstance. Gross variation in diet was therefore eliminated as far as possible thus creating reasonable experimental conditions.

MATERNAL WEIGHT GAIN DURING PREGNANCY.

The earliest observors noted that weight gains during pregnancy have exceeded that weight which can be accounted for by the growth of the foetus and the

other manifest and concrete products of pregnancy. It is not my purpose to speculate on the various factors which go to make up this weight gain, though in passing one might quote certain figures put forward by other writers. (Table I)

	Evans (I2) lb. oz.	Slemons & Fagan (35) lb. oz.	Granger * (I4) lb. oz.	Hannah (I8) lb. oz.	Hanley (I7) lb. oz.	Trillat (39) Kg.
Foetus	7 0	7 0	7 0		7 0	3.25
Placenta	I 8	I 8	I 8		I 3¼	0.5
Amniotic fluid.	2 8	I 8	I 8	I5 0	I 0	0.5
Increase in uterus & appendages	2 0	2 0	2 0		2 0	0.75
Breast & other tissue increase	2 - 4 lb.				++++	
Blood volume	I 9½	3 0	3 0		I 0	
Total	I7 9½	I5 0	I5 0	I5 0	I2 3¼ +	5.00 (or II lb.)

Table I.

It will be seen that all the above authors do not consider blood volume. Dieckmann and Wegner (II) quote the increase in blood volume as 23 %, and plasma, 25 %. Albers (I) states that before pregnancy the blood volume is 3.5 litres. This increases by

* See discussion by Dr.Mervyn V. Armstrong.

I litre during pregnancy, representing an increase 28.57 %. Evans[12] maintains that the increase in blood volume is 20 %.

As the mean maternal weight gain in this series is 24.7 lb., when all the factors in Table I are considered there is still at least 7 lb. unaccounted for.

Two factors to be considered are nitrogen retention and water retention, other than that covered by increased blood volume. Chesley[6], in a review of the literature, regards protein storage as accounting for at least 6 lb. of the average maternal gain (two thirds of which is outside the reproductive system). He also reports a variety of attempts to measure the interstitial fluid increase which fall outside the scope of this paper.

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The mean weight gain during normal pregnancy is stated variously by different authors to be between 13 and 30 lb.. Stander and Pastore[36], who give the highest figure quote 13.96 Kg (30.7 lb.) as being the average gain, but it should be noted that each of their patients received a quart of milk a day, which might account, at least in part, for this large weight increase. Hannah[18], on the

other hand, states that in a patient whose weight at the beginning of gestation is near standard, the gain for reproduction should not be more than I4 lb.. He quotes I3 lb. 4 oz. as the mean normal gain. Bingham (4) says that the average woman of medium size should not gain more than I5 - 20 lb. during her pregnancy, and Davis (9) takes a similar view, but quotes 20 lb. as the high limit of desired weight gain (though his mean weight gain is 2I lb. and many normal women in his series must have gained more than 20 lb.). Kerr (22) gives the mean gain as 22.9 lb. (in 500 primipara), Evans (I2) quotes I6.I8 lb. gain as normal, Slemons and Fagan (35) give I6½ lb. as the average maternal gain, Klein (24) 2I.05 lb. and Randall (32) 22.5 lb..

Table II shows briefly the gains recorded trimester by trimester.

Author	Mean weight gain (lb.)				Mean gain in last trimester (lb./week)
	Ist Trimest.	2nd Trimest.	3rd Trimest.	Total Gain	
Beardsley(2)	0.8	I2.4	II.6	24.8	0.87
Bingham (4)	2.9	I0.0	7.0	I9.9	0.53
Cummings(8)	0.45	I3.I3	I0.5	24.08	0.79
Dawson & Borg (I0)	0.45 (assumed)	I0.4	I4.0	24.85	I.05
Kerwin(23)	0.0	8.5	7.5	I6.5	0.56
Lawson(26)	0.0	I4.0	I0.5	24.5	0.79
Stander & Pastore(36)	2.7	I4.6	I3.4	30.7	I.0I
Tompkins & Wiehl (37)	3.0	II.0	I0.0	24.0	0.75
Waters(40)	3.2	8.0	I2.0	23.2	0.90
Chesley(6) (38 papers)	2.5	I0.8	II.2	24.0	0.86
Humphreys	0.0	I3.7I	I0.6	24.7	0.80

Table II.

The figures for the present series are given in Tables III and IV. One person only lost weight in pregnancy as a whole.

It will be seen from tables II, III, and IV that the mean weight gain during pregnancy in the present series bears a fairly close relationship to the mean of cases reviewed by Chesley[6] covering 38 papers. For comparison with other authors it should be noted that the summated means of the trimesters are not exactly equal to the total mean gain (vide Chesley, Kerwin, Humphreys.)

A further breakdown of weight gain into parities, in the current series, illustrates that the mean weight gain in primipara is 2.27 lb. greater than the mean weight gain in multipara. As this figure is 4.277 times the standard error of the difference it may be regarded as being statistically significant. This is by no means in accord with the observations of others. Gassner[13], Kemper[20], Kruger[25], Lorenzen[27], and Trillat[39] all record a greater weight gain in multipara, whereas Beardsley[2], Hanley[17], Hannah[18], Randall[32] and Zangemeister[42] record a greater weight gain in primipara. However, the statistical threads upon which many of the above authors hang their conclusions are rather slender, largely by way of

The frequency distribution of maternal weight gains in the second and third trimesters of normal pregnancy.

Weight gain (lb.)	Primipara 2nd Trimester	Primipara 3rd Trimester	Multipara 2nd Trimester	Multipara 3rd Trimester	All cases 2nd Trimester	All cases 3rd. Trimester
- I0-	0	0	I	0	I	0
- 5-	2	5	2	6	4	II
0-	23	5I	I5	83	38	I34
5-	96	I57	97	I86	I93	343
I0-	20I	I89	I9I	I3I	392	320
I5-	I38	89	I20	49	258	I38
20-	52	25	37	I5	89	40
25-	II	9	6	2	I7	II
30-	2	I	I	I	3	2
35-	I	0	3	I	4	I
40-	0	0	0	0	0	0
45-50	0	0	I	0	I	0
Total	526	526	474	474	I000	I000

Primipara Mean gain 2nd trimester = I3.83 lb.
S.D. = 5.65
Mean gain 3rd trimester = II.5I lb.
S.D. = 5.65

Multipara Mean gain 2nd trimester = I3.57 lb.
S.D. = 5.77
Mean gain 3rd trimester = 9.59 lb.
S.D. = 5.53

All cases Mean gain 2nd trimester = I3.7I lb.
S.D. = 5.7I
Mean gain 3rd trimester = I0.6 lb.
S.D. = 5.68

Table III.

The frequency distribution of total maternal weight gain during pregnancy.

Maternal gain (lb)	No. of Primipara	No. of Multipara	Total All cases
- I0-	0	I	I
- 5-	0	0	0
0-	5	0	5
5-	8	I5	23
I0-	36	50	86
I5-	78	95	I73
20-	II7	II8	235
25-	I25	III	236
30-	93	52	I45
35-	37	I7	54
40-	23	7	30
45-	2	3	5
50-	I	4	5
55-	0	0	0
60-65	I	I	2
Total	526	474	I000

Mean total weight gain (Primipara) = 25.77 lb.
S.D. = 8.44

Mean total weight gain (Multipara) = 23.5 lb.
S.D. = 8.33

Mean total weight gain (All cases) = 24.7 lb.
S.D. = 8.46

Table IV.

their reviewing so few cases.[X] Bray[5], Cummings[8], and Evans[12], do not feel that there is any statistically significant difference between the mean weight gain in primipara and multipara.

Mean weight gain per week during the last trimester.

A measure of more practical value than the observation of total weight gain during pregnancy is the rate of gain per week late in pregnancy. As toxaemias usually start late in pregnancy it is important that a normal rate of gain should be established. Accurate rates of weight gain are difficult to record, as most workers, including myself, have not recorded the week to week gain. This means that if one is to assess a mean weekly gain, one assumes that weight is gained at a standard steady rate (if one wishes to apply it to a particular week). This is obviously not so as is shown, for instance, by the ante-partum weight loss, the whole weight gain occurring in less than the trimester. Furthermore, without weekly weight recordings over the course of the last few weeks, one is unable to estimate the standard deviation of weekly gains.

Table II records the mean rate of gain in pounds per week during the last trimester, regardless of parity or age. The rate in the present series

X The former group of 5 papers review a mean of only (approx.) 164 patients each, and the latter rather more with (approx.) 304 each.

conforms fairly closely with the figures of most other authors. It is of interest at this stage to note that Granger [I4] regards a gain of more than I½ lb. per week in the last trimester as being due to water retention. This, he observes, is one of the earliest signs of toxaemia.

No standard deviation can be calculated, but the standard deviation of the mean gain for the whole of the last trimester is 5.68, from which one can calculate a coefficient of variation of 53.58 .

If the coefficient of variation for each week can be regarded as similar to that for the last trimester, the standard deviation is 0,43 .

One may summarise, then, by saying that the mean weight gain per week in the last trimester of pregnancy is 0.8 lb. (S.D. 0.43). This means that 95.45 % of normal cases would have a weekly gain less than I.66 lb. (more accurately between $0.8 \pm 2(0.43)$), a fairly close approximation to Granger's [I4] figure.

This however is rather speculative and could be regarded only as a very rough guide to the expected weekly rate of weight increase in the last trimester of normal pregnancy, if applied to any specific week.

PERCENTAGE MATERNAL WEIGHT GAIN.

In a frequently quoted paper, Stander and Pastore[36] state that " Throughout the study of these (2502) cases it was noted that the changes in weight were proportional to the original weight of the patient." On this basis they argue that maternal weight gain should be expressed as a percentage of prepregnant maternal weight. Though the latter suggestion is endorsed by later figures in this series, the former conclusion is not as shown in table V a, b, and c. From this table it will be seen that the correlation coefficient between prepregnant maternal weight and maternal weight gain during pregnancy is as follows :-

	Correlation coefficient	Correlation coeff. Standard error.
Primipara	0.075	I.72I
Multipara	-0.I26	2.74
All cases	-0.029	0.90I

These figures suggest that in the case of primipara and when all cases are taken together there is no significant relationship between prepregnant maternal weight and maternal weight gain. In the case of multipara there may, possibly, be some slight inverse relationship between prepregnant weight and weight gain, but it is doubtful if it is of real significance.

Dawson and Borg[IO] and Bray[5] fail to show any significant relationship, though the German writers,

Maternal weight gain during pregnancy and maternal weight at three months. Correlation coefficient.

Primipara.

3 month wt.(lb.)	Total weight gain (lb.)															Total.
	-10-	-5-	0-	5-	10-	15-	20-	25-	30-	35-	40-	45-	50-	55-	60-65	
70-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84-	0	0	0	0	0	5	8	2	4	0	0	0	0	0	0	19
98-	0	0	1	1	12	26	26	37	20	11	0	0	0	0	0	134
112-	0	0	1	2	9	21	35	40	34	13	4	1	0	0	1	161
126-	0	0	0	1	10	15	31	30	22	6	10	0	0	0	0	125
140-	0	0	3	3	1	7	8	10	8	5	3	1	1	0	0	50
154-	0	0	0	1	3	3	5	4	5	1	4	0	0	0	0	26
168-	0	0	0	0	1	1	3	2	0	1	2	0	0	0	0	10
182-	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
196-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210-224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	8	36	78	117	125	93	37	23	2	1	0	1	526

Mean total weight gain = 25.77 lb.
S.D. = 8.44
Mean weight at three months = 123.69 lb.
S.D. = 18.26
Correlation coefficient = 0.075.

Correlation coefficient / Standard error = 1.721

Table V (a)

Maternal weight gain during pregnancy and maternal weight at three months. Correlation coefficient.

Multipara.

3 month wt. (lb.)	Total weight gain. (lb.)															Total
	-I0-	-5-	0-	5-	I0-	I5-	20-	25-	30-	35-	40-	45-	50-	55-	60-65	
70-	0	0	0	0	0	0	I	0	0	0	0	0	0	0	0	I
84-	0	0	0	I	I	6	4	7	0	0	0	0	0	0	0	I9
98-	0	0	0	I	II	I4	3I	23	I4	4	I	0	I	0	I	I0I
II2-	0	0	0	2	I2	33	36	42	I8	4	5	2	2	0	0	I56
I26-	0	0	0	6	I0	22	30	26	I6	3	0	0	0	0	0	II3
I40-	0	0	0	2	II	II	9	6	2	5	I	I	0	0	0	48
I54-	I	0	0	2	0	6	3	3	2	I	0	0	I	0	0	I9
I68-	0	0	0	0	3	I	I	3	0	0	0	0	0	0	0	8
I82-	0	0	0	I	I	2	2	I	0	0	0	0	0	0	0	7
I96-	0	0	0	0	I	0	0	0	0	0	0	0	0	0	0	I
2I0-224	0	0	0	0	0	0	I	0	0	0	0	0	0	0	0	I
Total	I	0	0	I5	50	95	II8	III	52	I7	7	3	4	0	I	474

Mean total weight gain : 23.5 lb.
S.D. : 8.33
Mean weight at three months : I25.02 lb.
S.D. : I9.95
Correlation coefficient : -0.I26

Correlation coefficient / Standard error : 2.74

Table V (b)

Maternal weight gain during pregnancy and maternal weight at three months. Correlation coefficient.

All cases.

3 month weight. (lb.)	Total weight gain (lb.)															Total
	-10-	-5-	0-	5-	10-	15-	20-	25-	30-	35-	40-	45-	50-	55-	60-65	
70-	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
84-	0	0	0	1	1	11	12	9	4	0	0	0	0	0	0	38
98-	0	0	1	2	23	40	57	60	34	15	1	0	1	0	1	235
112-	0	0	1	4	21	54	71	82	52	17	9	3	2	0	1	317
126-	0	0	0	7	20	37	61	56	38	9	10	0	0	0	0	238
140-	0	0	3	5	12	18	17	16	10	10	4	2	1	0	0	98
154-	1	0	0	3	3	9	8	7	7	2	4	0	1	0	0	45
168-	0	0	0	0	4	2	4	5	0	1	2	0	0	0	0	18
182-	0	0	0	1	1	2	3	1	0	0	0	0	0	0	0	8
196-	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
210- 224	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Total	1	0	5	23	86	173	235	236	145	54	30	5	5	0	2	1000

Mean total weight gain = 24.7 lb.
S.D. = 8.46
Mean weight at three months = 124.32 lb.
S.D. = 19.1
Correlation coefficient = -0.029

Correlation coefficient
Standard error = 0.9

Table V (c)

Kemper[20], Zangemeister[43] and Lorenzen[27] hold that heavy women gain more than light. The reverse, that light women gain more than heavy during pregnancy, is demonstrated by Beardsley[2], McIlroy and Rodway[29] and Beilly and Kurland[3]. The only author to quote a correlation coefficient is Kerr[22]. His study was of primipara only and he calculated a correlation coefficient of 0.4, thus showing that the heavier women in his series gained more weight than the lighter ones.

The weight units used in the measurement of any mass are but arbitrary and it is quite reasonable to measure the maternal weight gain as a percentage of prepregnant maternal weight. Stander and Pastore[36] maintain that the maternal weight increase is 24.I % over all cases, and Wodon[4I] gives the gain as about 20 %. The percentage weight gains in this series are shown in Tables VI a, b and c.

It will be seen that the mean maternal weight gain in primipara is 2I.48 % (S.D. 7.I), and in multipara I9.76 % (S.D. 7.75). When all cases are considered together corresponding figures are 20.67 % (S.D. 7.46). As the difference in mean gain between primipara and multipara is 7.7 times its standard error it may be regarded as being of

Maternal weight gain during pregnancy (expressed as a percentage of prepregnant weight) and prepregnant weight of mother. Correlation coefficient.

Primipara.

% weight gain .	3 month maternal wt. (lb.)											Total
	70-	84-	98-	II2-	I26-	I40-	I54-	I68-	I82-	I96-	2I0-224	
-8 -	0	0	0	0	0	0	0	0	0	0	0	0
-4 -	0	0	0	0	0	0	0	0	0	0	0	0
0 -	0	0	I	0	0	3	0	0	0	0	0	4
4 -	0	0	0	I	2	3	2	0	0	0	0	8
8 -	0	0	6	6	9	2	5	2	I	0	0	3I
I2-	0	0	I3	I9	20	I2	7	3	0	0	0	74
I6-	0	4	23	26	38	II	4	2	0	0	0	I08
20-	0	4	23	4I	26	8	4	2	0	0	0	I08
24-	0	6	30	38	I7	6	4	I	0	0	0	I02
28-	0	I	23	2I	6	3	0	0	0	0	0	54
32-	0	3	I3	5	7	I	0	0	0	0	0	29
36-	0	I	2	3	0	I	0	0	0	0	0	7
40-	0	0	0	0	0	0	0	0	0	0	0	0
44-	0	0	0	0	0	0	0	0	0	0	0	0
48-	0	0	0	0	0	0	0	0	0	0	0	0
52-	0	0	0	I	0	0	0	0	0	0	0	I
56- 60	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	I9	I34	I6I	I25	60	26	I0	I	0	0	526

Mean maternal weight at three months = I23.68 lb.
S.D. = I8.26
Mean percentage weight gain (maternal) = 2I.48 %
S.D. = 7.I
Correlation coefficient = -0.33

Correlation coefficient = 9.436
Standard error

Table VI (a)

Marernal weight gain during pregnancy (expressed as a percentage of prepregnant weight) and prepregnant weight of mother. Correlation coefficient.

Multipara.

% weight gain.	3 month maternal weight (lb.)											Total
	70-	84-	98-	I12-	I26-	I40-	I54-	I68-	I82-	I96-	2I0-224	
-8 -	0	0	0	0	0	0	I	0	0	0	0	I
-4 -	0	0	0	0	0	0	0	0	0	0	0	0
0 -	0	0	0	0	0	0	0	0	0	0	0	0
4 -	0	I	0	2	7	4	2	2	2	I	0	2I
8 -	0	0	2	6	I2	I4	6	2	3	0	I	46
I2-	0	I	I7	30	27	I2	3	2	I	0	0	93
I6-	0	4	8	33	30	8	4	2	I	0	0	90
20-	0	2	28	39	I9	3	I	0	0	0	0	92
24-	I	6	20	27	I5	5	I	0	0	0	0	75
28-	0	4	9	9	3	I	0	0	0	0	0	26
32-	0	I	I3	3	0	I	I	0	0	0	0	I9
36-	0	0	2	4	0	0	0	0	0	0	0	6
40-	0	0	0	3	0	0	0	0	0	0	0	3
44-	0	0	0	0	0	0	0	0	0	0	0	0
48-	0	0	0	0	0	0	0	0	0	0	0	0
52-	0	0	I	0	0	0	0	0	0	0	0	I
56- 60	0	0	I	0	0	0	0	0	0	0	0	I
Total	I	I9	I0I	I56	II3	48	I9	8	7	I	I	474

Mean weight at three months = I25.02 lb.
S.D. = I9.95
Mean percentage weight gain(maternal) = I9.76%
S.D. = 7.75
Correlation coefficient = -0.45

Correlation coefficient
Standard error = 9.738

Table VI (b)

Maternal weight gain during pregnancy (expressed as a percentage of prepregnant weight) and prepregnant weight of mother. Correlation coefficient.

All cases.

% weight gain.	3 month maternal weight (lb.)											Total
	70-	84-	98-	II2-	I26-	I40-	I54-	I68-	I82-	I96-	2I0-224	
-8 - 0	0	0	0	0	0	0	I	0	0	0	0	I
-4 - 0	0	0	0	0	0	0	0	0	0	0	0	0
0 - 0	0	I	0	0	3	0	0	0	0	0	0	4
4 - 0	I	0	3	9	7	4	2	2	I	0		29
8 - 0	0	8	I2	2I	I6	II	4	4	0	I		77
I2- 0	I	30	49	47	24	I0	5	I	0	0		I67
I6- 0	8	3I	59	68	I9	8	4	I	0	0		I98
20- 0	6	5I	80	45	II	5	2	0	0	0		200
24- I	I2	50	65	32	II	5	I	0	0	0		I77
28- 0	5	32	30	9	4	0	0	0	0	0		80
32- 0	4	26	8	7	2	I	0	0	0	0		48
36- 0	I	4	7	0	I	0	0	0	0	0		I3
40- 0	0	0	3	0	0	0	0	0	0	0		3
44- 0	0	0	0	0	0	0	0	0	0	0		0
48- 0	0	0	0	0	0	0	0	0	0	0		0
52- 0	0	I	I	0	0	0	0	0	0	0		2
56- 0 60	0	I	0	0	0	0	0	0	0	0		I
Total I	38	235	317	238	98	45	I8	8	I	I		I000

Mean maternal weight at 3 months = I24.32 lb.
S.D. = I9.I
Mean percentage weight gain (maternal) = 20.67%
S.D. = 7.46
Correlation coefficient = -0.392

Correlation coefficient
Standard error = I2.39

Table VI (c)

statistical significance.

When the maternal weight gain expressed as a percentage of prepregnant maternal weight, is related to prepregnant maternal weight, the correlation coefficients are as follows :-

	Correlation coefficient	Corr. Coefficient Standard error
Primipara	-0.33	9.436
Multipara	-0.45	9.738
All cases	-0.39	I2.39

This demonstrates some small inverse relationship of statistical significance between percentage weight gain and prepregnant maternal weight, though this might be expected as one is partially relating the two factors by considering percentage weight gain before one starts comparing them.

MATERNAL WEIGHT GAIN AND DURATION OF LABOUR.

Not only do many women who gain an excessive amount of weight during pregnancy become the more easy victims of toxaemia, but it has been asserted that they are prone to have more difficult labours (Cummings[8], Bingham[4], Hannah[I8], Slemons and Fagan[35].) To relate maternal weight gain to method of delivery is not a satisfactory means of relating the two factors, as the method of delivery depends on so many diverse factors e.g. position of placenta and baby, previous obstetric experience of mother etc.. The duration of labour

does, however, give us some indication as to the ease, or otherwise, with which delivery is x effected, and has the advantage of being a a measurable quantity (in contrast to a 'method' of delivery) from which can be calculated a mathematical relationship. It has some of the limitations of calculations involving the method of delivery, but maternal weight gain, in pounds and as a percentage of prepregnant maternal weight, has been related to the duration of labour, and the results are shown in Tables VII a, b, and c and VIII a, b, and c.

It is apparent from these tables that when primipara and multipara are taken separately there is no statistically significant relationship between either actual weight gain or percentage weight gain on the one hand, and duration of labour on the other. When all cases are taken together the ratio, correlation coefficient/standard error is 2.57 when actual weight gain is considered, and 2.2 when percentage weight gain is considered. It seems very doubtful though if there is any real relationship between maternal weight gain and duration of labour. This corresponds with the opinion of Evans[12] and (with the exception of patients who gained 55 - 60 lb.) Waters[40].

Maternal weight gain in pregnancy and duration of labour. Correlation coefficient.

Primipara.

Duration labour. (Hours)	Total weight gain (lb.)															Total
	-10	-5	0-	5-	10-	15-	20-	25-	30-	35-	40-	45-	50-	55-	60-65	
0 -	0	0	I	I	3	7	8	4	4	0	I	0	0	0	0	29
5 -	0	0	2	I	I5	I7	I7	29	25	7	7	I	0	0	0	I2I
I0-	0	0	I	3	6	I9	3I	24	I6	9	5	I	0	0	I	II6
I5-	0	0	I	2	4	I0	20	II	I4	5	2	0	0	0	0	69
20-	0	0	0	0	4	9	I5	2I	II	I	5	0	0	0	0	66
25-	0	0	0	0	0	2	6	5	9	7	0	0	I	0	0	30
30-	0	0	0	0	2	3	4	5	3	I	2	0	0	0	0	20
35-	0	0	0	I	0	0	4	8	2	3	0	0	0	0	0	I8
40-	0	0	0	0	I	4	3	8	3	I	0	0	0	0	0	20
45-	0	0	0	0	0	I	2	2	2	0	0	0	0	0	0	7
50-	0	0	0	0	0	2	3	2	0	I	0	0	0	0	0	8
55-	0	0	0	0	0	I	0	2	0	I	I	0	0	0	0	5
60-	0	0	0	0	0	0	I	I	0	0	0	0	0	0	0	2
65-	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
70-	0	0	0	0	I	0	I	0	I	I	0	0	0	0	0	4
75-80	0	0	0	0	0	0	I	0	I	0	0	0	0	0	0	2
Over 80	0	0	0	0	0	2	I	3	0	0	0	0	0	0	0	6
Total	0	0	5	8	36	77	II7	I25	93	37	23	2	I	0	I	525

Labours over 80 hours duration.

Duration of labour. (Hrs.)	Weight gain. (lb.)
II2	I5-
II9.5	I5-
83.75	20-
84	25-
97.25	25-
I0I.5	25-

Mean duration of labour = I9.93 hours
S.D. = I6.37
Mean total weight gain = 25.79 lb.
S.D. = 8.44
Correlation coefficient = 0.05773

$$\frac{\text{Correlation coefficient}}{\text{Standard error}} = \text{I.32I}$$

One delivery was by Caesarian section.

Table VII (a)

Maternal weight gain in pregnancy and duration of labour. Correlation coefficient.

Multipara.

Duration labour. (Hours.)	Total weight gain (lb.)															Total
	-10-	-5-	0-	5-	10-	15-	20-	25-	30-	35-	40-	45-	50-	55-	60-65	
0 -	I	0	0	3	I3	33	29	20	I4	4	2	2	0	0	0	I2I
5 -	0	0	0	6	20	24	49	55	24	5	3	I	2	0	I	I90
I0-	0	0	0	4	7	2I	I7	I8	4	4	I	0	I	0	0	77
I5-	0	0	0	0	4	6	I0	I0	4	2	0	0	0	0	0	36
20-	0	0	0	2	3	7	5	3	4	I	I	0	I	0	0	27
25-	0	0	0	0	2	I	3	3	0	0	0	0	0	0	0	9
30-	0	0	0	0	0	2	2	I	0	I	0	0	0	0	0	6
35-	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
40-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45-	0	0	0	0	0	I	0	0	0	0	0	0	0	0	0	I
50-	0	0	0	0	I	0	0	I	0	0	0	0	0	0	0	2
55-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65-	0	0	0	0	0	0	0	0	I	0	0	0	0	0	0	I
70-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75-80	0	0	0	0	0	0	I	0	0	0	0	0	0	0	0	I
Over 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	I	0	0	I5	50	95	II8	III	5I	I7	7	3	4	0	I	473

Mean duration of labour	I0.03 hours
S.D.	8.6
Mean total weight gain	23.48 lb.
S.D.	8.32
Correlation coefficient	-0.004544
Correlation coefficient / Standard error	0.09872

One delivery was by Caesarian section

Table VII (b)

Maternal weight gain in pregnancy and duration of labour. Correlation coefficient.

All cases.

Duration labour. (Hours.)	Total weight gain. (lb.)															Total
	-10-	-5-	0-	5-	10-	15-	20-	25-	30-	35-	40-	45-	50-	55-	60-65	
0 -	1	0	1	4	16	40	37	24	18	4	3	2	0	0	0	150
5 -	0	0	2	7	35	41	66	84	49	12	10	2	2	0	1	311
10-	0	0	1	7	13	40	48	42	20	13	6	1	1	0	1	193
15-	0	0	1	2	8	16	30	21	18	7	2	0	0	0	0	105
20-	0	0	0	2	7	16	20	24	15	2	6	0	1	0	0	93
25-	0	0	0	0	2	3	9	8	9	7	0	0	1	0	0	39
30-	0	0	0	0	2	5	6	6	3	2	2	0	0	0	0	26
35-	0	0	0	1	0	0	6	8	2	3	0	0	0	0	0	20
40-	0	0	0	0	1	4	3	8	3	1	0	0	0	0	0	20
45-	0	0	0	0	0	2	2	2	2	0	0	0	0	0	0	8
50-	0	0	0	0	1	2	3	3	0	1	0	0	0	0	0	10
55-	0	0	0	0	0	1	0	2	0	1	1	0	0	0	0	5
60-	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	2
65-	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3
70-	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	4
75-80	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	3
Over 80	0	0	0	0	0	2	1	3	0	0	0	0	0	0	0	6
Total	1	0	5	23	86	172	235	236	144	54	30	5	5	0	2	998

Labours over 80 hours duration.

Duration of labour. (Hrs.)	Weight gain. (lb.)
112-	15-
119.5	15-
83.75	20-
84	25-
97.25	25-
101 .5	25-

Mean duration of labour = 15.24 hrs.
S.D. = 14.16
Mean total weight gain = 24.7 lb.
S.D. = 8.46
Correlation coefficient = 0.0812

Correlation coefficient / Standard error = 2.566

Two deliveries were by Caesarian section.

Table VII (c)

Maternal weight gain (expressed as a percentage of maternal weight at three months) and duration of labour. Correlation coefficient.

Primipara.

Duration of labour. (Hours.)	Maternal weight gain (%)																	Total
	-8-	-4-	0-	4-	8-	12-	16-	20-	24-	28-	32-	36-	40-	44-	48-	52-	56-60	
0 -	0	0	1	1	2	6	7	7	1	2	2	0	0	0	0	0	0	29
5 -	0	0	2	1	14	15	20	25	26	10	5	3	0	0	0	0	0	121
10-	0	0	1	3	5	18	24	21	21	14	6	2	0	0	0	1	0	116
15-	0	0	0	2	2	11	15	13	14	8	4	0	0	0	0	0	0	69
20-	0	0	0	0	3	8	18	16	13	4	4	0	0	0	0	0	0	66
25-	0	0	0	0	0	4	3	5	5	5	7	1	0	0	0	0	0	30
30-	0	0	0	0	0	3	6	6	2	3	0	0	0	0	0	0	0	20
35-	0	0	0	1	0	1	3	3	7	2	0	1	0	0	0	0	0	18
40-	0	0	0	0	2	3	4	5	5	1	0	0	0	0	0	0	0	20
45-	0	0	0	0	1	1	0	3	1	1	0	0	0	0	0	0	0	7
50-	0	0	0	0	0	1	5	0	1	1	0	0	0	0	0	0	0	8
55-	0	0	0	0	0	1	0	2	0	2	0	0	0	0	0	0	0	5
60-	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
65-	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	2
70-	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	4
75- 80	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2
Over 80	0	0	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0	6
Total	0	0	4	8	30	74	108	108	102	54	29	7	0	0	0	1	0	525

Labours over 80 hours duration.

Duration of labour.	Maternal weight gain.
112 hours	12- (%)
83.75 hours	16- (%)
119.5 hours	16- (%)
84 hours	24- (%)
97.25 hours	24- (%)
101.5 hours	24- (%)

Mean maternal weight gain = 21.5 %
S.D. = 7.09
Mean duration of labour = 19.93 hours
S.D. = 16.37
Correlation coefficient = 0.05

Correlation coefficient / Standard error = 1.2

One patient was delivered by Caesarian section.

Table VIII (a)

Maternal weight gain (expressed as a percentage of maternal weight at three months) and duration of labour. Correlation coefficient.

Multipara.

Duration of labour. (Hours.)	Maternal weight gain (%)																		Total
	-8	-4	-0	-4	-8	-12	-16	-20	-24	-28	-32	-36	-40	-44	-48	-52	-56	-60	
0 -	1	0	0	4	10	34	19	21	16	6	7	3	0	0	0	0	0		121
5 -	0	0	0	10	13	29	38	39	35	15	6	2	1	0	0	1	1		190
10-	0	0	0	4	12	13	17	12	11	3	3	1	1	0	0	0	0		77
15-	0	0	0	1	4	6	11	7	6	1	0	0	0	0	0	0	0		36
20-	0	0	0	2	4	6	2	6	3	1	2	0	1	0	0	0	0		27
25-	0	0	0	0	2	1	1	3	2	0	0	0	0	0	0	0	0		9
30-	0	0	0	0	0	4	0	0	2	0	0	0	0	0	0	0	0		6
35-	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0		2
40-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
45-	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		1
50-	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0		2
55-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
60-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
65-	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		1
70-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
75-80	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		1
Over 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Total	1	0	0	21	46	93	90	91	75	26	19	6	3	0	0	1	1		473

Mean maternal weight gain = 19.76 %
S.D. = 7.75
Mean duration of labour = 10.03 hrs.
S.D. = 8.6
Correlation coefficient = 0.014

Correlation coefficient
Standard error = 0.3042

One patient was delivered by Caesarian section.

Table VIII(b)

Maternal weight gain (expressed as a percentage of maternal weight at three months) and duration of labour. Correlation coefficient.

All cases .

Duration of labour. (Hours.)	Maternal weight gain. (%)																	Total
	-8	-4	0	4	8	12	16	20	24	28	32	36	40	44	48	52	56-60	
0 -	I	0	I	5	I2	40	26	28	I7	8	9	3	0	0	0	0	0	I50
5 -	0	0	2	II	27	44	58	64	6I	25	II	5	I	0	0	I	I	3II
I0-	0	0	I	7	I7	3I	4I	33	32	I7	9	3	I	0	0	I	0	I93
I5-	0	0	0	3	6	I7	26	20	20	9	4	0	0	0	0	0	0	I05
20-	0	0	0	2	7	I4	20	22	I6	5	6	0	I	0	0	0	0	93
25-	0	0	0	0	2	5	4	8	7	5	7	I	0	0	0	0	0	39
30-	0	0	0	0	0	7	6	6	4	3	0	0	0	0	0	0	0	26
35-	0	0	0	I	0	I	3	5	7	2	0	I	0	0	0	0	0	20
40-	0	0	0	0	2	3	4	5	5	I	0	0	0	0	0	0	0	20
45-	0	0	0	0	I	I	I	3	I	I	0	0	0	0	0	0	0	8
50-	0	0	0	0	I	I	5	I	I	I	0	0	0	0	0	0	0	I0
55-	0	0	0	0	0	I	0	2	0	2	0	0	0	0	0	0	0	5
60-	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
65-	0	0	0	0	0	0	0	0	I	I	I	0	0	0	0	0	0	3
70-	0	0	0	0	I	I	0	0	2	0	0	0	0	0	0	0	0	4
75-80	0	0	0	0	0	0	2	0	0	0	I	0	0	0	0	0	0	3
Over 80	0	0	0	0	0	I	2	0	3	0	0	0	0	0	0	0	0	6
Total	I	0	4	29	76	I67	I98	I99	I77	80	48	I3	3	0	0	2	I	998

Labours over 80 hours duration .

Duration of labour.(Hrs.)	Maternal wt. gain .(%)
II2	I2-
83.75	I6-
II9.5	I6-
84	24-
97.25	24-
I0I.5	24-

Mean maternal weight gain = 20.68 %
S.D. = I.86
Mean duration of labour = I5.24 hours
S.D. = I4.I6
Correlation coefficient = 0.07

Correlation coefficient
Standard error = 2.2

Two patients were delivered by Caesarian section .

Table VIII (c)

It is of interest at this point, that the mean duration of labour is as follows :-

	Duration of labour.(Hrs.)	S.D.
Primipara	I9.93	I6.37
Multipara	I0.03	8.6
All cases	I5.24	I4.I6

The more rapid labours of multipara compared with primipara are of manifest statistical significance, the difference between the mean duration of labour in primipara and the mean in multipara being I4.85 times the standard error of the difference.

BIRTH WEIGHT AND DURATION OF LABOUR.

As there appears to be no relationship between maternal weight gain and duration of labour one might now consider the relationship between foetal birth weight and duration of labour. (For this purpose, the birth weight of twins is regarded as being equal to the summated weights of both twins.) This relationship is illustrated in Table IX a, b, and c.

The correlation coefficients are very small, and any one may easily have arisen by chance.

There is, therefore, no real relationship in this series between foetal birth weight and duration of labour. This apparent heresy militates strongly against the view held by so many that large babies

Duration of labour and foetal birth weight. Correlation coefficient.

Primipara.

Duration labour. (Hours.)	Foetal birth weight. (lb.)																	Total.
	4-	4½-	5-	5½-	6-	6½-	7-	7½-	8-	8½-	9-	9½-	10-	10½-	11-	11½-	12	
0 -	0	0	1	3	5	7	5	4	1	2	0	1	0	0	0	0		29
5 -	0	2	5	11	22	20	21	17	11	6	4	1	0	1	0	0		121
10-	0	0	2	4	19	17	29	25	12	5	3	0	0	0	0	0		116
15-	0	1	4	3	8	13	14	13	6	2	5	0	0	0	0	0		69
20-	0	0	1	6	7	16	10	16	6	3	1	0	0	0	0	0		66
25-	0	0	2	2	1	5	8	7	4	1	0	0	0	0	0	0		30
30-	0	0	0	0	3	7	2	4	3	0	1	0	0	0	0	0		20
35-	0	0	1	0	3	2	5	3	3	1	0	0	0	0	0	0		18
40-	0	0	1	2	4	2	4	3	3	1	0	0	0	0	0	0		20
45-	0	0	0	0	0	3	0	0	3	0	0	1	0	0	0	0		7
50-	0	1	0	0	1	1	4	0	0	1	0	0	0	0	0	0		8
55-	0	0	0	1	0	0	1	0	1	2	0	0	0	0	0	0		5
60-	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0		2
65-	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0		2
70-	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0		4
75-80	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0		2
Over 80	0	0	0	1	1	2	1	0	0	1	0	0	0	0	0	0		6
Total	0	4	17	33	74	96	106	95	55	26	15	3	0	1	0	0		525

Labours over 80 hours duration.

Duration of labour (Hrs.)	Foetal birth weight (lb.)
83.75	5½-
112	6 -
84	6½-
101.5	6½-
119.5	7 -
97.25	8½-

Mean foetal birth weight : 7.19 lb.
S.D. : 0.97
Mean duration of labour : 19.93 hours
S.D. : 16.37
Correlation coefficient : 0.07

Correlation coefficient
Standard error : 1.6

One delivery was by Caesarian section.

Table IX (a)

Duration of labour and foetal birth weight. Correlation coefficient.

Multipara.

Duration labour. (Hours.)	Foetal birth weight. (lb.)																							Total.
	4½-	5-	5½-	6-	6½-	7-	7½-	8-	8½-	9-	9½-	10-	10½-	11-	11½-	12-	12½-	13						
0 -	0	0	7	15	19	22	25	11	8	10	2	0	0	0	1	0	1							121
5 -	0	5	9	20	17	48	39	23	16	7	5	0	1	0	0	0	0							190
10-	1	1	1	10	12	12	12	12	11	1	2	1	0	1	0	0	0							77
15-	1	0	0	2	5	7	6	8	3	2	2	0	0	0	0	0	0							36
20-	0	0	1	1	5	5	3	9	0	1	2	0	0	0	0	0	0							27
25-	0	1	1	0	3	1	0	1	2	0	0	0	0	0	0	0	0							9
30-	0	0	0	0	2	0	2	0	1	0	0	1	0	0	0	0	0							6
35-	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0							2
40-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0
45-	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0							1
50-	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0							2
55-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0
60-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0
65-	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0							1
70-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0
75-80	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0							1
Over 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0
Total	3	7	19	48	64	97	87	65	43	21	13	2	1	1	1	0	1							473

Mean foetal birth weight = 7.55 lb.
S.D. = 1.09
Mean duration of labour = 10.03 hours
S.D. = 8.6
Correlation coefficient = 0.035

$\frac{\text{Correlation coefficient}}{\text{Standard error}}$ = 0.7605

One delivery was by Caesarian section.

Table IX (b)

Duration of labour and foetal birth weight. Correlation coefficient.

All cases.

Duration labour. (Hours.)	Foetal birth weight. (lb.)																	Total
	4½ -	5 -	5½ -	6 -	6½ -	7 -	7½ -	8 -	8½ -	9 -	9½ -	10 -	10½ -	11 -	11½ -	12 -	12½ -13	
0 -	0	1	10	20	26	27	29	12	10	10	3	0	0	0	1	0	1	150
5 -	2	10	20	42	37	69	56	34	22	11	6	0	2	0	0	0	0	311
10-	1	3	5	29	29	41	37	24	16	4	2	1	0	1	0	0	0	193
15-	2	4	3	10	18	21	19	14	5	7	2	0	0	0	0	0	0	105
20-	0	1	7	8	21	15	19	15	3	2	2	0	0	0	0	0	0	93
25-	0	3	3	1	8	9	7	5	3	0	0	0	0	0	0	0	0	39
30-	0	0	0	3	9	2	6	3	1	1	0	1	0	0	0	0	0	26
35-	0	1	0	3	3	6	3	3	1	0	0	0	0	0	0	0	0	20
40-	0	1	2	4	2	4	3	3	1	0	0	0	0	0	0	0	0	20
45-	0	0	0	0	3	1	0	3	0	0	1	0	0	0	0	0	0	8
50-	2	0	0	1	1	4	0	0	2	0	0	0	0	0	0	0	0	10
55-	0	0	1	0	0	1	0	1	2	0	0	0	0	0	0	0	0	5
60-	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2
65-	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	3
70-	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	4
75-80	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	3
Over 80	0	0	1	1	2	1	0	0	1	0	0	0	0	0	0	0	0	6
Total	7	24	52	122	160	203	182	120	69	36	16	2	2	1	1	0	1	998

Labours over 80 hours duration.

Duration of labour. (Hrs.)	Foetal birth weight (lb)
83.75	5½ -
112	6 -
84	6½ -
101.5	6½ -
119.5	7 -
97.25	8½ -

Mean foetal birth weight = 7.36 lb.
S.D. = 1.04
Mean duration of labour = 15.24 hours.
S.D. = 14.16
Correlation coefficient = 0.01

$$\frac{\text{Correlation coefficient}}{\text{Standard error}} = 0.3155$$

Two deliveries were by Caesarian section.

Table IX (c)

predispose to prolonged labours, though the only author who has, so far as I am aware, calculated a correlation coefficient states that there is no relationship between size of infant and length of labour. (Kerr(22)) His cases were all primipara.

RELATIONSHIP OF FOETAL BIRTH WEIGHT TO MATERNAL WEIGHT GAIN.

To the practicing obstetrician a matter of frequent interest is the weight of an expected baby. The mechanical devices of science can give no estimate of the weight of a child 'in utero', and it has been the object of many workers to establish some relationship between factors which can be measured, principally maternal weight gain, and the weight of the foetus at birth. Some workers, notably McIlroy and Rodway (29), Klein (24), and Dawson and Borg (10) fail to demonstrate any relationship between these factors, though the premises on which they reach their conclusions would bear some investigation. None of them estimates a correlation coefficient. Dawson and Borg (10), in a series of 770 cases, estimate a mean weight gain during pregnancy of 24.85 lb.. They then take an arbitrary amount, 30 lb., and show that the mean foetal birth weight for 50 women who

gained more than 30 lb. was 7 lb. 9 oz., whereas the mean foetal birth weight for 50 women who gained less than 30 lb. was 7 lb. 8 oz.. The method of selection of these 100 women is not stated.

Toombs (38) and Klein (24) study the problem from a similar, though not identical, aspect. Toombs (38) shows that 58 % of his patients gained less than 20 lb. during pregnancy, and 42 % gained more than 20 lb., though 68.8 % of babies weighed 7 lb. or more at birth. Klein (24) states that 57.67 % of his mothers gained 20 or more pounds compared with 42.33 % whose weight gain was less than 20 lb.. Yet 67.72 % of his babies weighed 7 lb. or more at birth whereas 32.28 % weighed less than 7 lb.. Klein then produces tables of maternal weight gain showing no relationship to foetal birth weight in the varying degrees of weight gain. He also reviews six papers covering 2914 cases and relates mean weight gain in lb. to birth weight in lb.. In this review he fails to show any relationship between the two factors. On the basis of these arguments he asserts that, " There is no correlation between the maternal weight gain during pregnancy and the weight of the baby at birth".

The results of these last quoted papers must be considered in the light of the arbitrary figures

from which they take measurement. As these figures vary, so may the conclusions which are drawn from figures based upon them.

Beardsley[2] and Waters[40] fail to show any real relationshop between maternal weight gain and foetal birth weight, though Waters does record heavier babies as being born to women who gain 55 - 60 lb. during pregnancy. Cummings[8], Davis[9], Bingham[4], Hanley[17], Slemons and Fagan[35] and Trillat[39] all conclude some degree of relationship between their maternal and foetal weight factors. Beilly and Kurland[3] calculate a correlation coefficient of 0.184928 for maternal weight gain and foetal birth weight, while Kerr[22], in an outstanding review of 500 normal primipara records a correlation coefficient of 0.53 between percentage weight gain and infant weight. For actual weight gain and infant weight his correlation coefficient is 0.28.

In the present series, correlation coefficients for percentage maternal weight gain and foetal birth weight, and actual weight gain and foetal birth weight are shown in Tables X a, b and c and XI a, b and c for primipara, multipara and all cases.

It is quite apparent from these tables that there is a small, but statistically significant relationship between maternal weight gain during

Maternal weight gain in pregnancy (expressed as a percentage of maternal weight at three months) and foetal birth weight. Correlation coefficient.

Primipara.

% maternal gain	Foetal birth weight (lb.)																	Total
	4½-	5-	5½-	6-	6½-	7-	7½-	8-	8½-	9-	9½-	10-	10½-	11-	11½-	12-	12½-	13
-8 - 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-4 - 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0 - 0	0	0	I	2	I	0	0	0	0	0	0	0	0	0	0	0	0	4
4 - 0	0	2	I	I	2	0	I	0	I	0	0	0	0	0	0	0	0	8
8 - 0	4	4	6	6	4	4	I	I	0	0	0	0	0	I	0	0	0	3I
I2- 2	4	7	I2	I4	I2	II	5	5	2	0	0	0	0	0	0	0	0	74
I6- I	3	I0	20	23	23	I7	5	5	I	0	0	0	0	0	0	0	0	I08
20- 0	2	6	I9	20	25	I7	I0	4	3	2	0	0	0	0	0	0	0	I08
24- I	I	4	9	22	20	I9	I6	5	5	0	0	0	0	0	0	0	0	I02
28- 0	I	0	5	5	II	I9	6	4	3	0	0	0	0	0	0	0	0	54
32- 0	2	0	I	3	7	6	7	2	0	0	0	I	0	0	0	0	0	29
36- 0	0	0	0	0	I	2	3	0	0	I	0	0	0	0	0	0	0	7
40- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52- 0	0	0	0	0	0	0	0	I	0	0	0	0	0	0	0	0	0	I
56- 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60																		
Total 4	I	733		7496		I0695		5526		I53		0	I	0	I	0	0	526

Mean foetal birth weight = 7.2 lb.
S.D. = 0.99
Mean maternal weight gain = 2I.48 %
S.D. = 7.I
Correlation coefficient = 0.26

Correlation coefficient / Standard error = 5.96

Table X (a)

Maternal weight gain in pregnancy (expressed as a percentage of maternal weight at three months) and foetal birth weight. Correlation coefficient.

Multipara.

% maternal gain .	Foetal birth weight (lb.)																			Total
	4½-	5-	5½-	6-	6½-	7-	7½-	8-	8½-	9-	9½-	10-	10½-	11-	11½-	12-	12½-	13		
-8 -	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0			1
-4 -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
0 -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
4 -	0	0	1	4	3	5	3	1	4	0	0	0	0	0	0	0	0			21
8 -	0	0	0	7	6	10	9	8	5	1	0	0	0	0	0	0	0			46
12-	0	1	7	10	14	21	18	9	5	4	2	1	0	1	0	0	0			93
16-	1	5	4	11	11	16	15	11	4	6	6	0	0	0	0	0	0			90
20-	2	1	3	6	17	15	23	11	6	5	3	0	0	0	0	0	0			92
24-	0	0	4	5	10	19	8	11	1	4	2	0	0	0	0	0	1			75
28-	0	0	0	3	0	6	6	4	5	1	1	0	0	0	0	0	0			26
32-	0	0	0	2	1	5	3	4	2	0	0	0	1	0	1	0	0			19
36-	0	0	0	0	1	0	1	3	0	0	0	1	0	0	0	0	0			6
40-	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0			3
44-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
48-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
52-	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0			1
56- 60	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0			1
Total	3	7	19	48	64	97	87	65	43	21	14	2	1	1	1	0	1			474

Mean foetal birth weight = 7.55 lb.
S.D. = 1.09
Mean maternal weight gain = 19.76 %
S.D. = 7.75
Correlation coefficient = 0.16

$$\frac{\text{Correlation coefficient}}{\text{Standard error}} = 3.48$$

Table X (b)

Maternal weight gain in pregnancy (expressed as a percentage of maternal weight at three months) and foetal birth weight. Correlation coefficient.

All cases.

% maternal gain .	Foetal birth weight (lb.)																			Total
	4½ -	5-	5½ -	6-	6½ -	7-	7½ -	8-	8½ -	9-	9½ -	10-	10½ -	11-	11½ -	12-	12½ -13			
-8 -	0	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0			I
-4 -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
0 -	0	0	0	I	2	I	0	0	0	0	0	0	0	0	0	0	0			4
4 -	0	0	3	5	4	7	3	2	4	I	0	0	0	0	0	0	0			29
8 -	0	4	4	I3	I2	I4	I3	9	6	I	0	0	0	0	I	0	0			77
I2-	2	5	I4	22	28	33	29	I4	I0	6	2	I	0	I	0	0	0			I67
I6-	2	8	I4	3I	34	39	32	I6	9	7	6	0	0	0	0	0	0			I98
20-	2	3	9	25	37	40	40	2I	I0	8	5	0	0	0	0	0	0			200
24-	I	I	8	I4	32	39	27	27	I6	9	2	0	0	0	0	0	I			I77
28-	0	I	0	8	5	I7	25	I0	9	4	I	0	0	0	0	0	0			80
32-	0	2	0	3	4	I2	9	II	4	0	0	0	2	0	I	0	0			48
36-	0	0	0	0	I	I	3	6	0	0	I	I	0	0	0	0	0			I3
40-	0	0	0	0	0	0	I	2	0	0	0	0	0	0	0	0	0			3
44-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
48-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0
52-	0	0	0	0	0	0	0	I	I	0	0	0	0	0	0	0	0			2
56- 60	0	0	0	0	0	0	0	I	0	0	0	0	0	0	0	0	0			I
Total	7	24	52	I22	I60	203	I82	I20	69	36	I7	2	2	I	2	0	I			I000

Mean foetal birth weight = 7.37 lb.
S.D. = I.05
Mean maternal weight gain = 20.67 %
S.D. = 7.46
Correlation coefficient = 0.I8

Correlation coefficient / Standard error = 5.69

Table (X) c .

Maternal weight gain during pregnancy and foetal birth weight. Correlation coefficient.

Primipara.

Maternal wt. gain (lb.)	Foetal birth weight (lb.)																									Total
	4½-		5-		5½-		6-		6½-		7-		7½-		8-		8½-		9-		9½-		10-		10½-		11-		11½-		12-		12½-	13	
-10 -	0		0	0		0	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
- 5 -	0		0	0		0	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
0 -	0		0	0		0	I		2		2		0		0		0		0		0		0		0		0		0		0		0		5
5 -	0		I	I		2	I		2		0		I		0		0		0		0		0		0		0		0		0		0		8
10-	I		3	5		8	6		5		5		I		I		I		0		0		0		0		0		0		0		0		36
15-	2		5	7		I9	I8		I2		8		3		2		I		0		0		0		0		I		0		0		0		78
20-	0		4	I3		I8	27		23		20		5		5		2		0		0		0		0		0		0		0		0		II7
25-	I		I	7		I6	24		29		2I		I6		8		I		I		0		0		0		0		0		0		0		I25
30-	0		0	0		I0	I5		2I		26		I3		4		3		I		0		0		0		0		0		0		0		93
35-	0		3	0		0	2		9		7		9		4		2		I		0		0		0		0		0		0		0		37
40-	0		0	0		0	I		3		7		5		2		5		0		0		0		0		0		0		0		0		23
45-	0		0	0		0	0		0		0		I		0		0		0		I		0		0		0		0		0		0		2
50-	0		0	0		0	0		0		I		0		0		0		0		0		0		0		0		0		0		0		I
55-	0		0	0		0	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0
60-65	0		0	0		0	0		0		0		I		0		0		0		0		0		0		0		0		0		0		I
Total	4		I7	33		74	96		I06		95		55		26		I5		3		I		0		I		0		I		0		0		526

Mean maternal weight gain = 25.77 lb.
S.D. = 8.44
Mean foetal birth weight = 7.2 lb.
S.D. = 0.99
Correlation coefficient = 0.38

Correlation coefficient
Standard error = 8.7

Table XI (a)

Maternal weight gain during pregnancy and foetal birth weight. Correlation coefficient.

Multipara.

Maternal wt. gain (lb.)	Foetal birth weight (lb.)																									Total
	4½-		5-		5½-		6-		6½-		7-		7½-		8-		8½-		9-		9½-		10-		10½-		11-		11½-		12-		12½-	13	
-10 -	0		0	0		0		1		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		1
- 5 -	0		0	0		0		0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0
0 -	0		0	0		0		0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0
5 -	0		0	0		5		3		3	1		0	3		0	0		0	0		0	0		0	0		0	0		0	0		15
10-	0		0	2		6		7		13	11		8	3		0	0		0	0		0	0		0	0		0	0		0	0		50
15-	1		2	8		16		16		18	14		10	5		4	1		0	0		0	0		0	0		0	0		0	0		95
20-	1		3	4		12		17		27	26		11	6		5	4		1	0		1	0		0	0		0	0		0	0		118
25-	1		2	3		6		15		20	22		18	13		6	5		0	0		0	0		0	0		0	0		0	0		111
30-	0		0	2		2		4		12	6		7	9		5	4		0	0		0	0		0	0		0	0		0	1		52
35-	0		0	0		1		0		2	5		5	3		1	0		0	0		0	0		0	0		0	0		0	0		17
40-	0		0	0		0		1		2	0		3	0		0	0		1	0		0	0		0	0		0	0		0	0		7
45-	0		0	0		0		0		0	2		0	0		0	0		0	0		0	0		0	1		0	0		0	0		3
50-	0		0	0		0		0		0	0		2	1		0	0		0	1		0	0		0	0		0	0		0	0		4
55-	0		0	0		0		0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0
60-65	0		0	0		0		0		0	0		1	0		0	0		0	0		0	0		0	0		0	0		0	0		1
Total	3		7	19		48		64		97	87		65	43		21	14		2	1		1	1		0	1								474

Mean maternal weight gain = 23.5 lb.
S.D. = 8.33
Mean foetal birth weight = 7.55 lb.
S.D. = 1.09
Correlation coefficient = 0.29

$$\frac{\text{Correlation coefficient}}{\text{Standard error}} = 6.314$$

Table XI (b)

Maternal weight gain during pregnancy and foetal birth weight. Correlation coefficient.

All cases.

Maternal wt. gain (lb.)	Foetal birth weight (lb.)																	Total
	4½-	5-	5½-	6-	6½-	7-	7½-	8-	8½-	9-	9½-	10-	10½-	11-	11½-	12-	12½-13	
- 10-	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
- 5-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0-	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	5
5-	0	1	1	7	4	5	1	1	3	0	0	0	0	0	0	0	0	23
10-	1	3	7	14	13	18	16	9	4	1	0	0	0	0	0	0	0	86
15-	3	7	15	35	34	30	22	13	7	5	1	0	0	0	1	0	0	173
20-	1	7	17	30	44	50	46	16	11	7	4	1	0	1	0	0	0	235
25-	2	3	10	22	39	49	43	34	21	7	6	0	0	0	0	0	0	236
30-	0	0	2	12	19	33	32	20	13	8	5	0	0	0	0	0	1	145
35-	0	3	0	1	2	11	12	14	7	3	1	0	0	0	0	0	0	54
40-	0	0	0	0	2	5	7	8	2	5	0	1	0	0	0	0	0	30
45-	0	0	0	0	0	0	2	1	0	0	0	0	1	0	1	0	0	5
50-	0	0	0	0	0	0	1	2	1	0	0	0	1	0	0	0	0	5
55-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60-65	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Total	7	24	52	122	160	203	182	120	69	36	17	2	2	1	2	0	1	1000

Mean maternal weight gain = 24.7 lb.
S.D. = 8.46
Mean foetal birth weight = 7.37 lb.
S.D. = 1.05
Correlation coefficient = 0.31

Correlation coefficient
Standard error = 9.8

Table XI (c)

pregnancy, expressed both as a percentage of prepregnant maternal weight, and in pounds, on the one hand and foetal birth weight on the other.

As maternal weight gain has been expressed as a percentage of prepregnant maternal weight, it is reasonable that one should next consider infant weight as a percentage of maternal weight gain. Tables XII a, b and c show the degree of correlation between these two factors.

Considerable and significant relationship may be seen to exist between the percentage maternal weight gain and the weight of their offsprings at birth, expressed as a percentage of maternal weight gain.

Having established correlation coefficients of statistical significance between the factor of weight gain during pregnancy and the foetal birth w weight factor, both expressed in various ways, it remains to calculate regression equations and regression coefficients. As part of the available data in all cases is the parity of the woman, regression coefficients are calculated only for primipara and multipara.

Consider, for instance, the simplest example, that of maternal weight gain in pounds and the

Maternal weight gain (expressed as a percentage of maternal weight at three months) and foetal birth weight (expressed as a percentage of maternal gain). Correlation coefficient.

Primipara.

Birth wt. as % of maternal gain.	Maternal weight gain (%) ← -8	-4	-0	-4	-8	-I2	-I6	-20	-24	-28	-32	-36	-40	-44	-48	-52	-56	-60	Total
Less than 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
0 -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I0 -	0	0	0	0	0	0	0	3	7	I3	I4	5	0	0	0	I	0		43
20 -	0	0	0	0	0	5	49	75	89	4I	I5	2	0	0	0	0	0		276
30 -	0	0	0	0	6	43	54	30	5	0	0	0	0	0	0	0	0		I38
40 -	0	0	0	I	9	2I	5	0	0	0	0	0	0	0	0	0	0		36
50 -	0	0	0	0	I0	3	0	0	0	0	0	0	0	0	0	0	0		I3
60 -	0	0	0	I	5	2	0	0	0	0	0	0	0	0	0	0	0		8
70 -	0	0	0	I	I	0	0	0	0	0	0	0	0	0	0	0	0		2
80 -	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0		I
90 -	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0		I
I00-	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0		2
II0-	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0		I
I20-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I30-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I40-	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0		I
I50-I60	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0		I
Over I60	0	0	2	0	0	0	0	0	I	0	0	0	0	0	0	0	0		3
Total	0	0	4	8	3I	74	I08	I08	I02	54	29	7	0	0	0	I	0		526

Birth weights of over I60% maternal wt. gain.

Birth wt. as % mat. gain.	Maternal gain (%)
I87.5 %	0 -
I94.7 %	0 -
24I.7 %	24-

Mean maternal wt. gain (%) = 2I.48 %
S.D. = 7.I
Mean birth wt. as % maternal gain = 3I.96 %
S.D. = I9.5I
Correlation coefficient = -0.56

Correlation coefficient
Standard error = I2.82

Table XII (a)

Maternal weight gain (expressed as a percentage of maternal weight at three months) and foetal birth weight (expressed as a percentage of maternal gain). Correlation coefficient.

Multipara.

Birth wt. as % of maternal gain.	Maternal weight gain (%)																	Total
	-8	-4	-0	-4	-8	-I2	-I6	-20	-24	-28	-32	-36	-40	-44	-48	-52	-56	-60	
Less than 0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		I
0 -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I0 -	0	0	0	0	0	0	0	I	3	3	5	4	3	0	0	I	I		2I
20 -	0	0	0	0	0	I	I9	52	6I	23	I4	2	0	0	0	0	0		I72
30 -	0	0	0	0	6	36	62	39	I0	0	0	0	0	0	0	0	0		I53
40 -	0	0	0	I	II	46	9	0	I	0	0	0	0	0	0	0	0		68
50 -	0	0	0	I	I9	I0	0	0	0	0	0	0	0	0	0	0	0		30
60 -	0	0	0	3	9	0	0	0	0	0	0	0	0	0	0	0	0		I2
70 -	0	0	0	5	I	0	0	0	0	0	0	0	0	0	0	0	0		6
80 -	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0		3
90 -	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0		3
I00-	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0		3
II0-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I20-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I30-	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0		I
I40-	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0		I
I50-I60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Over I60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Total	I	0	0	2I	46	93	90	92	75	26	I9	6	3	0	0	I	I		474

In one case there was a loss of weight in pregnancy. The foetal birth weight was 87.08 % of this loss.

Mean maternal weight gain (%) = I9.76 %
S.D. = 7.75
Mean birth wt. as % maternal gain = 35.8 %
S.D. = I6.67
Correlation coefficient = -0.65

Correlation coefficient
Standard error = I4.I4

Table XII (b)

Maternal weight gain (expressed as a percentage of maternal weight at three months) and foetal birth weight (expressed as a percentage of maternal gain). Correlation coefficient.

All cases.

Birth wt. as % of maternal gain.	Maternal weight gain (%)																		Total.
	-8	-4	-0	-4	-8	-I2	-I6	-20	-24	-28	-32	-36	-40	-44	-48	-52	-56	-60	
Less than 0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		I
0 -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I0 -	0	0	0	0	0	0	0	4	I0	I6	I9	9	3	0	0	2	I		64
20 -	0	0	0	0	0	6	68	I27	I50	64	29	4	0	0	0	0	0		448
30 -	0	0	0	0	I2	79	II6	69	I5	0	0	0	0	0	0	0	0		29I
40 -	0	0	0	2	20	67	I4	0	I	0	0	0	0	0	0	0	0		I04
50 -	0	0	0	I	29	I3	0	0	0	0	0	0	0	0	0	0	0		43
60 -	0	0	0	4	I4	2	0	0	0	0	0	0	0	0	0	0	0		20
70 -	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0		8
80 -	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0		4
90 -	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0		4
I00-	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0		5
II0-	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0		I
I20-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
I30-	0	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0		I
I40-	0	0	I	I	0	0	0	0	0	0	0	0	0	0	0	0	0		2
I50- I60	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0		I
Over I60	0	0	2	0	0	0	0	0	I	0	0	0	0	0	0	0	0		3
Total	I	0	4	29	77	I67	I98	200	I77	80	48	I3	3	0	0	2	I		I000

Birth weights over I60% maternal wt. gain.

Birth wt. as % mat. gain.	Maternal gain (%)
I87.5 %	0 -
I94.7 %	0 -
24I.7 %	24-

In one case there was a loss of weight in pregnancy. The foetal birth weight was 87.08 % of this loss.

Mean maternal weight gain (%)	=	20.67 %
S.D.	=	7.46
Mean birth wt. as % maternal gain	=	33.78 %
S.D.	=	I8.3I
Correlation coefficient	=	-0.6
Correlation coefficient Standard error	=	I8.97

Table XII (c)

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foetal birth weight, also in pounds. From the data available in table XI a one can construct a regression equation for primipara as follows :-

Birth wt. - 7.2 = 0.38 X $\frac{0.99}{8.44}$ X (maternal gain - 25.87)

Birth wt. - 7.2 = 0.04458maternal gain - I.I49

Birth wt. (lb.) = 0.04458maternal gain (lb.) + 6.05I

Regression coefficient = 0.04458

Using a similar technique the regression equation in multipara for maternal weight gain in pounds and foetal birth weight in pounds (see Table XI b) is :-

Birth wt. (lb.) = 0.03795maternal gain(lb.) + 6.652I

Regression coefficient = 0.03795

If we consider next the relationship between maternal weight gain expressed as a percentage of prepregnant maternal weight, and foetal birth weight in pounds, the regression equations become (see Tables X a and b) :-

<u>Primipara</u>

Birth wt.(lb.) = 0.03624maternal gain (%) + 6.42I5

Regression coefficient = 0.03624

<u>Multipara</u>

Birth wt.(lb.) = 0.0225maternal gain (%) + 7.I054

Regression coefficient = 0.0225

Lastly we might consider the relationship between maternal weight gain expressed as a percentage of prepregnant maternal weight, and foetal birth weight expressed as a percentage of maternal weight gain. (Tables XII a and b.) The regression equations are :-

Primipara

Birth wt. (% mat.gain) = -I.538maternal gain(%)+65.0I

Regression coefficient = -I.538

Multipara

Birth wt. (% mat.gain) = -I.398maternal gain(%)+63.43

Regression coefficient = -I.398

It is not suggested that when applied to the individual case the use of the regression coefficient gives a standard of change in birth weight for unit change in maternal gain, but it does illustrate a tendency and has been used clinically with results as accurate as any other method of estimation of baby weight, including clinical judgement. Gross errors do of course occur in individual cases, even when three regression equations are applied and compared.

THE RELATIONSHIP OF MATERNAL WEIGHT GAIN DURING PREGNANCY TO AGE OF MOTHER.

As with so many aspect of weight gain during pregnancy, opinions vary as to the relationship between weight gain and the age of the mother. Klein[24] maintains that " There is no relationship between the age of the mother, her weight gain during pregnancy and the weight of the newborn infant." Kemper[20] states that age does not influence weight gain during the last four months of pregnancy, which view is supported by the work of Bray[5]. Most other writers, however, maintain that young women gain more weight than older ones - Siddall and Mack[33], Dawson and Borg[10], Waters[40] and McIlroy and Rodway[29].

Tables XIII a, b, and c show the figures for the current series. It should be noted that the youngest patient was I4 years old at both conception and delivery, but as she fulfilled all the necessary requirements she was included.

The correlation coefficients for primipara and multipara are low, and of negative sign. They are, on purely mathematical grounds, unlikely to have arisen by chance but the margin of significance is very small. However, when the greater age range of 'all patients' is considered the correlation coefficient of -0.I4 is 4.5 times its

Maternal weight gain in pregnancy and age of mother. Correlation coefficient.

Primipara.

Mat.wt. gain. lb.	Age in years.											Total.
	I3-I6-	I9-	22-	25-	28-	3I-	34-	37-	40-	43-45		
-I0-	0	0	0	0	0	0	0	0	0	0	0	0
- 5-	0	0	0	0	0	0	0	0	0	0	0	0
0-	0	0	2	0	0	0	3	0	0	0	0	5
5-	0	0	2	2	0	2	0	I	0	I	0	8
I0-	0	I	6	I5	8	4	I	I	0	0	0	36
I5-	I	0	I4	I5	25	II	4	3	3	2	0	78
20-	0	I	27	32	I9	I8	II	9	0	0	0	II7
25-	0	2	25	3I	33	22	6	5	I	0	0	I25
30-	0	3	I3	33	I8	I8	2	4	2	0	0	93
35-	0	0	4	I4	9	7	2	I	0	0	0	37
40-	0	0	7	5	8	3	0	0	0	0	0	23
45-	0	0	0	I	I	0	0	0	0	0	0	2
50-	0	I	0	0	0	0	0	0	0	0	0	I
55-	0	0	0	0	0	0	0	0	0	0	0	0
60-65	0	I	0	0	0	0	0	0	0	0	0	I
Total	I	9	I00	I48	I2I	85	29	24	6	3	0	526

Age = age last birthday on first ante-natal visit.

Mean age on first ante-natal visit = 25.79 years
S.D. = 4.54
Mean maternal weight gain = 25.77 lb.
S.D. = 8.44
Correlation coefficient = -0.09

$$\frac{\text{Correlation coefficient}}{\text{Standard error}} = 2.052$$

Table XIII (a)

Maternal weight gain in pregnancy and age of mother. Correlation coefficient.

Multipara.

Mat.wt. gain. lb.	Age in years.											Total
	I3-I6		I9-22		25-28		3I-34		37-40		43-45	
-I0-	0	0	0	0	0	0	I	0	0	0	0	I
- 5-	0	0	0	0	0	0	0	0	0	0	0	0
0-	0	0	0	0	0	0	0	0	0	0	0	0
5-	0	0	0	I	2	I	5	4	2	0	0	I5
I0-	0	0	2	8	II	II	5	6	4	3	0	50
I5-	0	0	5	II	I9	24	I8	I0	4	3	I	95
20-	0	0	4	20	27	26	20	I3	3	3	2	II8
25-	0	0	3	I8	25	32	I2	I2	7	2	0	III
30-	0	0	7	8	I2	6	I3	5	I	0	0	52
35-	0	0	0	2	5	5	2	I	2	0	0	I7
40-	0	0	0	3	I	2	0	0	0	I	0	7
45-	0	0	0	0	I	I	0	I	0	0	0	3
50-	0	0	0	2	0	2	0	0	0	0	0	4
55-	0	0	0	0	0	0	0	0	0	0	0	0
60-65	0	0	0	0	0	I	0	0	0	0	0	I
Total	0	0	2I	73	I03	III	76	52	23	I2	3	474

Age = age last birthday on first ante-natal visit.

Mean age on first ante-natal visit = 29.5 years
S.D. = 5.05
Mean maternal weight gain = 23.5 lb.
S.D. = 8.33
Correlation coefficient = -0.I2

$$\frac{\text{Correlation coefficient}}{\text{Standard error}} = 2.6$$

Table XIII (b)

Maternal weight gain in pregnancy and age of mother. Correlation coefficient.

All cases.

Mat.wt. gain. lb.	Age in years.											Total
	I3-I6	I6-I9	I9-22	22-25	25-28	28-3I	3I-34	34-37	37-40	40-43	43-45	
-I0-	0	0	0	0	0	0	I	0	0	0	0	I
- 5-	0	0	0	0	0	0	0	0	0	0	0	0
0-	0	0	2	0	0	0	3	0	0	0	0	5
5-	0	0	2	3	2	3	5	5	2	I	0	23
I0-	0	I	8	23	I9	I5	6	7	4	3	0	86
I5-	I	0	I9	26	44	35	22	I3	7	5	I	I73
20-	0	I	3I	52	46	44	3I	22	3	3	2	235
25-	0	2	28	49	58	54	I8	I7	8	2	0	236
30-	0	3	20	4I	30	24	I5	9	3	0	0	I45
35-	0	0	4	I6	I4	I2	4	2	2	0	0	54
40-	0	0	7	8	9	5	0	0	0	I	0	30
45-	0	0	0	I	2	I	0	I	0	0	0	5
50-	0	I	0	2	0	2	0	0	0	0	0	5
55-	0	0	0	0	0	0	0	0	0	0	0	0
60-65	0	I	0	0	I	0	0	0	0	0	0	2
Total	I	9	I2I	22I	225	I95	I05	76	29	I5	3	I000

Age = age last birthday on first ante-natal visit.

Mean age on first ante-natal visit = 27.54 years
S.D. = 5.I3
Mean maternal weight gain = 24.7 lb.
S.D. = 8.46
Correlation coefficient = -0.I4

$$\frac{\text{Correlation coefficient}}{\text{Standard error}} = 4.5$$

Table XIII (c)

standard error, and must be regarded as significant. Therefore we may conclude, in agreement with the authors quoted, that young women tend to gain more weight during pregnancy than older ones.

WEIGHT OF INFANTS AT BIRTH.

Having considered the various aspects of maternal weight gain, it remains to study matters relating to the birth weight of infants.

BIRTH WEIGHT RELATED TO SEX OF INFANT.

All workers are agreed that boys tend to weigh more at birth than girls. Table XIV shows at a glance the figures from a fairly wide range of the literature.

Author	Number of cases	Mean birth wt.(Males) lb.	oz.	Mean birth wt.(Females) lb.	oz.
(2) Beardsley	200	7	II¼	7	6½
Beilly & Kurland(3)	979	7	5	7	0
X Hanley(I7)	482	7	9	7	2
Hannah(I8)	236	7	I5	7	6
Klein (24)	567	7	8½	7	4
McIlroy & Rodway (29)	I000	7	5	7	2
Humphreys	I000	7	9	7	2½

Table XIV

The present series covered I000 mothers who gave birth to I002 babies, 499 boys and 503 girls. Table XV shows the frequency distribution of these babies' weights at birth and the results are

X Klein quotes Hanley's means as 7lb.I0oz. for boys and 7lb.3oz. for girls. These are 'unweighted means'. The true 'weighted means' are shown above.

The frequency distribution of foetal birth weight.

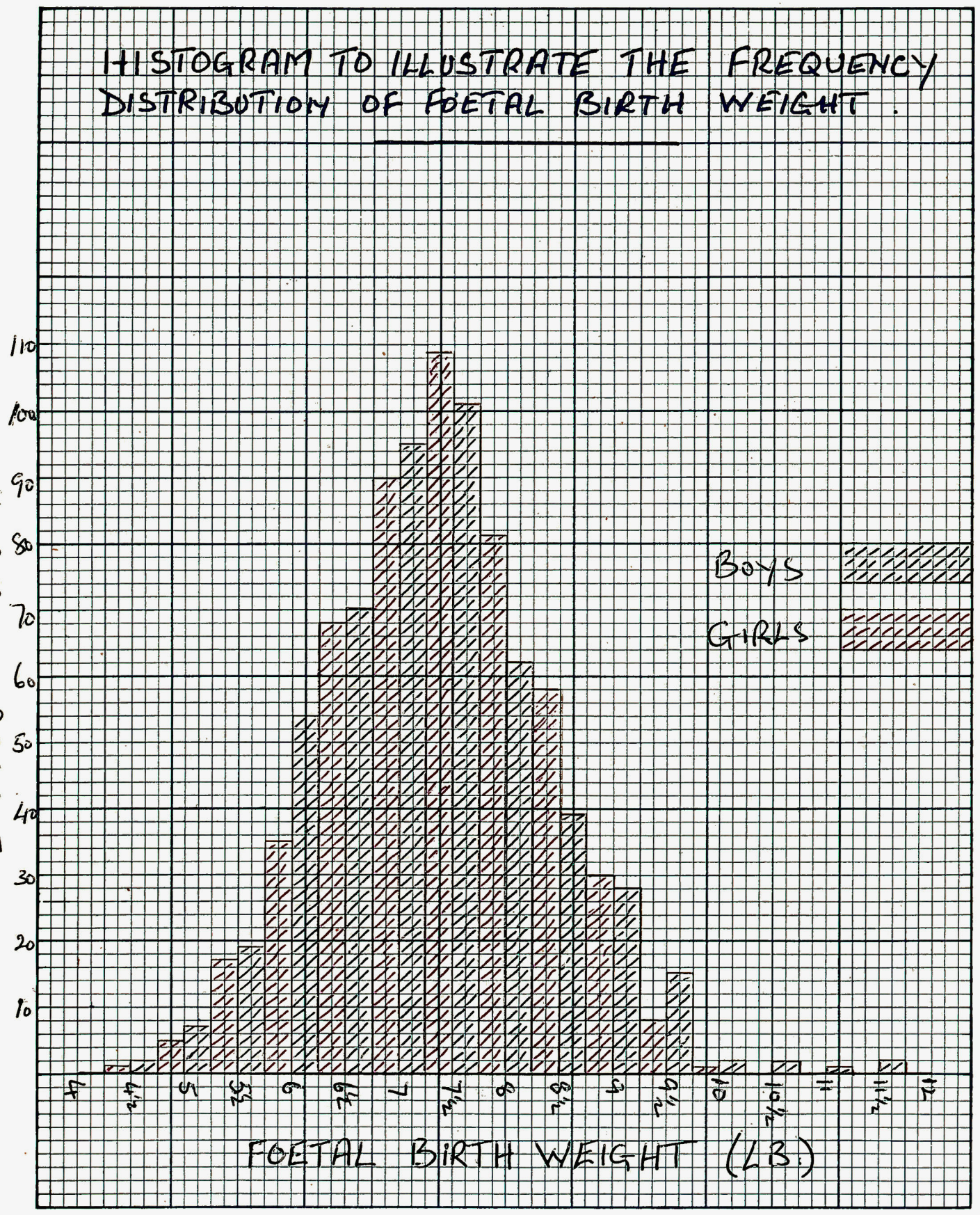
Birth weight (lb.)	Number of boys	Number of girls.	All infants
4 -	0	I	I
4½ -	2	5	7
5 -	7	I7	24
5½ -	I9	35	54
6 -	54	68	I22
6½ -	70	90	I60
7 -	95	I09	204
7½ -	I0I	8I	I82
8 -	62	58	I20
8½ -	39	30	69
9 -	28	8	36
9½ -	I5	I	I6
I0 -	2	0	2
I0½-	2	0	2
II -	I	0	I
II½-I2	2	0	2
Total	499	503	I002

Mean weight of boys at birth = 7.56 lb.
S.D. = I.09
Mean weight of girls at birth = 7.I5 lb.
S.D. = 0.95
Mean weight of all infants at birth = 7.35 lb.
S.D. = I.04

Weight of boys - weight of girls = 6.346 (standard error)

Table XV.

HISTOGRAM TO ILLUSTRATE THE FREQUENCY DISTRIBUTION OF FOETAL BIRTH WEIGHT.



amplified by the histogram opposite. This shows quite clearly the increased incidence of girls in the lower weight groups and of boys in the higher groups.

It will be seen that the mean weight of boys at birth is 0.4I lb. more than the weight of girls at birth. As this figure is 6.346 times the standard error of the difference we may conclude that the mean weight of boys at birth is more than the mean weight of girls by a statistically significant amount.

BIRTH WEIGHT RELATED TO MATERNAL AGE AND PARITY.

When considering foetal birth weight in relation to maternal weight gain the following figures were given(Table XI a, b, and c) :-

Parity	Number of cases.	Mean birth wt. (lb.)	S.D.
Primipara	526	7.2	0.99
Multipara	474	7.55	I.09
All cases	I000	7.37	I.05

Multipara, therefore, gain 0.35 lb. produce children whose mean birth weight is 0.35 lb. more than the children of primipara. This figure is unlikely to have arisen by chance as the difference is 5.294 times its standard error. For comparison with other authors see Table XVI.

Author	Foetal birth wt. Primipara lb. oz.	Foetal birth wt. Multipara lb. oz.
Bingham (4)	7 3	7 6
Hanley (I7)	7 4	7 8
Hannah (I8)	7 I2½	7 I5¾
Klein (24)	7 5	7 8½

Table XVI.

Having arrived at this conclusion, which seems in harmony with that of other workers, one must now consider the distinct factors of age and parity. Naturally most multiparous patients are going to be older than most primiparous patients. In this series it has already been shown that the mean age for primipara is 25.79 years (S.D. 4.54) whereas the mean age for multipara is 29.5 years (S.D.5.05). (Table XIII). It is possible therefore, that the increased mean birth weight of babies born to multipara may be related to age more than parity. To separate these two factors Table XVII has been constructed.

This table illustrates that there is no relationship whatever between birth weight and maternal age when parity is fixed - columns reading horizontally. In the columns reading vertically however, there is a tendency for the means to increase as one reads downwards i.e. for the mean birth weight to increase as parity rises, when age is fixed. This is most noticeable in the

Mean birth weight in pounds related to maternal age and parity.

Parity	Maternal age (years)						All ages
	22 & under	23-24	25-26	27-29	30-34	35 & over	
I	7.36 ±0.160	7.14 ±0.193	7.19 ±0.228	7.10 ±0.204	7.20 ±0.224	6.88 ±0.325	7.2 ± 0.083
2	7.29 ±0.429	7.58 ±0.322	7.78 ±0.294	7.56 ±0.202	7.32 ±0.228	7.48 ±0.382	7.50 ± 0.116
3	8.38 ±0.650	6.92 ±1.559	7.56 ±0.563	7.48 ±0.378	7.77 ±0.407	7.65 ±0.434	7.64 ± 0.209
4 & over	- -	7.25 I case	- -	7.18 ±0.554	7.39 ±0.742	8.33 ±0.768	7.81 ± 0.469
All parities	7.37 ±0.151	7.28 ±0.167	7.42 ±0.176	7.33 ±0.134	7.37 ±0.152	7.50 ±0.244	7.37 ± 0.066

Table XVII

last column where all ages are considered together (though this cannot be regarded as a true test of 'fixed age'). It should be noted that on a statistical basis these figures may have arisen by chance. This may possibly be due to an inadequate number of cases in the higher parities, and if more material had been available similar mean weights may have assumed more significant proportions. This suspicion is supported by reference to a paper by McKeown and Gibson[30]. In a series of 19,414 births their figures are :-

Parity.	Mean birth weight (lb.) All ages.
1	7.17 ± 0.014
2	7.46 ± 0.017
3	7.65 ± 0.026
4 & over	7.65 ± 0.026
All parities	7.41 ± 0.009

They illustrate similar tendencies in the separate age groups, and conclude that :-

"(a) (birth) weight increases with parity (to the third birth rank.)

(b) there is no consistent association between (birth) weight and maternal age."

The figures in this series are only remotely suggestive of this and are produced only for comparison and not as a scientific revelation. Larger numbers are required to give them statistical backing.

SUMMARY AND CONCLUSIONS.

The literature covers a considerable amount of work on the maternal and foetal weight factors during pregnancy and in the puerperium, though much that has been written is of little statistical value. An attempt has been made to study these factors and produce statistically acceptable results for normal cases. This analysis of normal cases seems desirable as a basis for so much research that has yet to be done on abnormal weight gain, water retention, adrenal control of water and nitrogen balance etc..

The mean weight gains and standard deviations in the last two trimesters of normal pregnancy, and in normal pregnancy as a whole are calculated, and the mean weight gain in primipara and multipara compared. The mean weight gain expressed as a percentage of prepregnant maternal weight is also calculated and the gain in primipara and multipara compared. In both instances primipara are shown to have a higher mean gain than multipara by a statistically significant amount.

The mean weekly weight gain and standard deviation for the last trimester are calculated speculatively.

It is not possible to demonstrate any really

significant relationship between prepregnant maternal weight and maternal weight gain during pregnancy, though when maternal weight gain is expressed as a percentage of prepregnant maternal weight there is some slight inverse relationship.

The mean duration of labour is calculated and that of primipara and multipara compared, confirming the longer mean duration of labour in primipara. The maternal weight gain in pounds, and as a percentage, is then correlated with the duration of labour and when all cases are considered together there is some very slight direct relationship of doubtful significance.

Foetal birth weight is also correlated with duration of labour. No significant relationship is demonstrable.

Correlation coefficients, regression equations and regression coefficients are calculated for maternal weight gain and foetal birth weight. The former is variously presented as pounds and as a percentage of prepregnant maternal weight. The latter is presented as pounds and as a percentage of maternal weight gain. Significant relationship is demonstrated between the maternal and foetal weight factors in all the combinations .

Correlation coefficients are calculated for

maternal weight gain and age of mother. It is shown that younger women gain more weight than older women (when parity is ignored) by a significant amount.

The mean birth weight is calculated for boys, girls, the babies of primipara, the babies of multipara and for all babies together. The mean weight of boys is shown to be more at birth than girls by an amount which is unlikely to have arisen by chance. Multipara are shown to have babies of a heavier mean weight than primipara. The amount is statistically significant. The possibility that this may be related to parity rather than age is considered.

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